

AMENDMENTS TO THE CLAIMS:

This listing of claims will replace all prior versions, and listings, of claims in the application:

1. (Previously presented) An ignition apparatus having a spark plug comprising:
a mounting bracket to be mounted to an internal combustion engine;
a center electrode insulatedly-supported by the mounting bracket, one end of which being a cylindrical form and exposedly extending from one end of the mounting bracket; and

an earth electrode having one end coupled with the one end of the mounting bracket and the other end on which one surface is formed to face to the one end of the center electrode, the one surface having a cylindrical protrusion being secured thereon and extending toward the center electrode so as to face the one end of the center electrode, a spacing formed between the one end of the center electrode and the protrusion of the earth electrode and formed to serve as a discharge gap, both of the one end of the center electrode and the protrusion of the earth electrode being 2.3 mm or less in diameter to keep an amount of ignition energy supplied to the spark plug below 17 mJ.

2. (Previously presented) An ignition apparatus having a spark plug comprising:
a mounting bracket to be mounted to an internal combustion engine;
a center electrode insulatedly-supported by the mounting bracket, one end of which being a cylindrical form and exposedly extending from one end of the mounting bracket; and

an earth electrode having one end coupled with the one end of the mounting bracket and the other end on which one surface is formed to face to the one end of the center electrode, the one surface having a cylindrical protrusion being secured thereon and extending toward the center electrode so as to face the one end of the center

electrode, a spacing formed between the one end of the center electrode and the protrusion of the earth electrode and formed to serve as a discharge gap, both of the one end of the center electrode and the protrusion of the earth electrode being 2.3 mm or less in diameter, and a density of ignition energy supplied to the spark plug being less than 32 W.

Claims 3-7. (Canceled).

8. (Previously presented) An ignition apparatus comprising:
a spark plug comprising:
a mounting bracket to be mounted to an internal combustion engine;
a center electrode insulatedly-supported by the mounting bracket, one end of which being a cylindrical form and exposedly extending from one end of the mounting bracket; and
an earth electrode having one end coupled with the one end of the mounting bracket and the other end on which one surface is formed to face to the one end of the center electrode, the one surface having a cylindrical protrusion being secured thereon and extending toward the center electrode so as to face the one end of the center electrode, a spacing formed between the one end of the center electrode and the protrusion of the earth electrode and formed to serve as a discharge gap, both of the one end of the center electrode and the protrusion of the earth electrode being 2.3 mm or less in diameter, and the discharge gap being 0.7 mm or less in length; and
an ignition power supply for applying voltage to the center electrode and the earth electrode so that the voltage is applied across the discharge gap, an amount of ignition energy supplied from the ignition power supply to the spark plug being lower than 17 mJ.

9. (Previously presented) An ignition apparatus comprising:
a spark plug comprising:

a mounting bracket to be mounted to an internal combustion engine;
a center electrode insulatedly-supported by the mounting bracket, one end of which being a cylindrical form and exposedly extending from one end of the mounting bracket; and

an earth electrode having one end coupled with the one end of the mounting bracket and the other end on which one surface is formed to face to the one end of the center electrode, the one surface having a cylindrical protrusion being secured thereon and extending toward the center electrode so as to face the one end of the center electrode, a spacing formed between the one end of the center electrode and the protrusion of the earth electrode and formed to serve as a discharge gap, both of the one end of the center electrode and the protrusion of the earth electrode being 2.3 mm or less in diameter, and the discharge gap being 0.7 mm or less in length; and

an ignition power supply having an ignition coil for applying voltage to the center electrode and the earth electrode so that the voltage is applied across the discharge gap, the ignition coil being 22 mm or less in coil diameter and an amount of ignition energy supplied from the ignition power supply to the spark plug being lower than 17 mJ.

10. (Previously presented) An ignition apparatus comprising:

a spark plug having:

a mounting bracket to be mounted to an internal combustion engine,
a center electrode insulatedly-supported by the mounting bracket, one end of which being a cylindrical form and exposedly extending from one end of the mounting bracket, and

an earth electrode having one end coupled with the one end of the mounting bracket and the other end on which one surface is formed to face to the one end of the center electrode, the one surface having a cylindrical protrusion being secured thereon and extending toward the center electrode so as to face the one end of the center electrode, a spacing formed between the one end of the center electrode and the

protrusion of the earth electrode and formed to serve as a discharge gap, both of the one end of the center electrode and the protrusion of the earth electrode being 2.3 mm or less in diameter, and the protrusion being made of one selected from a group consisting of a platinum-based alloy and an iridium-based alloy; and

an ignition power supply for applying voltage to the center electrode and the earth electrode so that the voltage is applied across the discharge gap, a positive potential of the voltage being applied to the center electrode by the ignition power supply when a discharge starts in the discharge gap, and an amount of ignition energy supplied from the ignition power supply to the spark plug being lower than 17 mJ.

11. (Previously presented) The ignition apparatus of claim 1, wherein both of the one end of the center electrode and the protrusion of the earth electrode are 1.1 mm or less in diameter.

12. (Previously presented) An ignition apparatus having a spark plug comprising:

a mounting bracket to be mounted to an internal combustion engine;
a center electrode insulatedly-supported by the mounting bracket, one end of which being a pillar-like form and exposedly extending from one end of the mounting bracket; and

an earth electrode having one end coupled with the one end of the mounting bracket and the other end on which one surface is formed to face to the one end of the center electrode, the one surface having a pillar-like protrusion being secured thereon and extending toward the center electrode so as to face the one end of the center electrode, a spacing formed between the one end of the center electrode and the protrusion of the earth electrode and formed to serve as a discharge gap, both of the one end of the center electrode and the protrusion of the earth electrode being a sectional area of 4.2 mm^2 or less at all positions each perpendicularly crossing an axial

direction of each of the one end and the protrusion to keep an amount of ignition energy supplied to the spark plug below 17 mJ.

13. (Previously presented) An ignition apparatus having a spark plug comprising:

- a mounting bracket to be mounted to an internal combustion engine;
- a center electrode insulatedly-supported by the mounting bracket, one end of which being a pillar-like form and exposedly extending from one end of the mounting bracket; and

- an earth electrode having one end coupled with the one end of the mounting bracket and the other end on which one surface is formed to face to the one end of the center electrode, the one surface having a pillar-like protrusion being secured thereon and extending toward the center electrode so as to face the one end of the center electrode, a spacing formed between the one end of the center electrode and the protrusion of the earth electrode and formed to serve as a discharge gap, both of the one end of the center electrode and the protrusion of the earth electrode being a sectional area of 4.2 mm^2 or less at all positions each perpendicularly crossing an axial direction of each of the one end and the protrusion, and a density of ignition energy supplied to the spark plug being less than 32 W.

Claims 14-18. (Canceled).

19. (Previously presented) An ignition apparatus comprising:

- a spark plug comprising:

- a mounting bracket to be mounted to an internal combustion engine; a center electrode insulatedly-supported by the mounting bracket, one end of which being a pillar-like form and exposedly extending from one end of the mounting bracket; and an earth electrode having one end coupled with the one end of the mounting bracket and the other end on which one surface is formed to face to the one end of the center

electrode, the one surface having a pillar-like protrusion being secured thereon and extending toward the center electrode so as to face the one end of the center electrode, a spacing formed between the one end of the center electrode and the protrusion of the earth electrode and formed to serve as a discharge gap, both of the one end of the center electrode and the protrusion of the earth electrode being a sectional area of 4.2 mm^2 or less at all positions each perpendicularly crossing an axial direction of each of the one end and the protrusion, and the discharge gap being 0.7 mm or less in length; and

an ignition power supply for applying voltage to the center electrode and the earth electrode so that the voltage is applied across the discharge gap, an amount of ignition energy supplied from the ignition power supply to the spark plug being lower than 17 mJ.

20. (Previously presented) An ignition apparatus comprising:

a spark plug comprising:

a mounting bracket to be mounted to an internal combustion engine;

a center electrode insulatedly-supported by the mounting bracket, one end of which being a pillar-like form and exposedly extending from one end of the mounting bracket; and

an earth electrode having one end coupled with the one end of the mounting bracket and the other end on which one surface is formed to face to the one end of the center electrode, the one surface having a pillar-like protrusion being secured thereon and extending toward the center electrode so as to face the one end of the center electrode, a spacing formed between the one end of the center electrode and the protrusion of the earth electrode and formed to serve as a discharge gap, both of the one end of the center electrode and the protrusion of the earth electrode being a sectional area of 4.2 mm^2 or less at all positions each perpendicularly crossing an axial direction of each of the one end and the protrusion, and the discharge gap being 0.7 mm or less in length; and

an ignition power supply having an ignition coil for applying voltage to the center electrode and the earth electrode so that the voltage is applied across the discharge gap, the ignition coil being 22 mm or less in coil diameter and an amount of ignition energy supplied from the ignition power supply to the spark plug being lower than 17 mJ.

21. (Previously presented) An ignition apparatus comprising:

a spark plug having:

a mounting bracket to be mounted to an internal combustion engine,

a center electrode insulatedly-supported by the mounting bracket, one end of which being a pillar-like form and exposedly extending from one end of the mounting bracket, and

an earth electrode having one end coupled with the one end of the mounting bracket and the other end on which one surface is formed to face to the one end of the center electrode, the one surface having a pillar-like protrusion being secured thereon and extending toward the center electrode so as to face the one end of the center electrode, a spacing formed between the one end of the center electrode and the protrusion of the earth electrode and formed to serve as a discharge gap, both of the one end of the center electrode and the protrusion of the earth electrode being a sectional area of 4.2 mm^2 or less at all positions each perpendicularly crossing an axial direction of each of the one end and the protrusion, and the protrusion being made of one selected from a group consisting of a platinum-based alloy and an iridium-based alloy; and

an ignition power supply for applying voltage to the center electrode and the earth electrode so that the voltage is applied across the discharge gap, a positive potential of the voltage being applied to the center electrode by the ignition power supply when a discharge starts in the discharge gap, and an amount of ignition energy supplied from the ignition power to the spark plug being lower than 17 mJ.

22. (Previously presented) The ignition apparatus of claim 12, wherein both of the one end of the center electrode and the protrusion of the earth electrode are a sectional area of 1 mm^2 or less at all positions each perpendicularly crossing an axial direction of each of the one end and the protrusion.

23. (Previously presented) An ignition apparatus having a spark plug comprising:

a mounting bracket capable of being mounted to an internal combustion engine;
a center electrode insulatedly-supported by the mounting bracket, one end of which being a cylindrical form and exposedly extending from one end of the mounting bracket; and

an earth electrode having one end coupled with the one end of the mounting bracket and the other end on which one surface is formed to face to the one end of the center electrode, the one surface having a cylindrical protrusion being secured thereon and extending toward the center electrode so as to face the one end of the center electrode, wherein an ignition energy $E \text{ mJ}$ is applied to the spark plug so that an ignition occurs between the center and earth electrodes, a diameter D of the protrusion is 2.3 mm or less, and relationships of

$$0.3 \text{ mm} \leq L \leq 0.016E^2 - 0.56E + 5.2 \text{ mm}$$

$$\text{in which } 8.5 \text{ mJ} \leq E \leq 17 \text{ mJ}$$

are realized between a length L of the protrusion and the ignition energy $E \text{ mJ}$.

24. (Previously presented) The ignition apparatus of claim 23, wherein both of the one end of the center electrode and the protrusion of earth electrode are 4.2 mm^2 or less in sectional area and a density of the ignition energy is 32 W or less.

25. (Previously presented) The ignition apparatus of claim 23, wherein both of a diameter $D1$ of the one end of the center electrode and a diameter $D2$ of the protrusion of earth electrode are 2.3 mm or less and a relationship of

$$1.5D_2^2 + 0.1D_2 + 8 \text{ mJ} \leq E < 0.34D_1^2 + 0.2D_1 + 16.4 \text{ mJ}$$

between the ignition energy E mJ and the diameters D1 and D2 is realized.

26. (Previously presented) The ignition apparatus of claim 23, wherein both of a diameter D1 of the one end of the center electrode and a diameter D2 of the protrusion of the earth electrode are 2.3 mm or less and a relationship of

$$3D_2^2 + 0.2D_2 + 16 \text{ W} \leq Q < 0.68D_1^2 + 0.4D_1 + 32.8 \text{ W}$$

between the density of the ignition energy Q W and the diameters D1 and D2 is realized.

27. (Previously presented) The ignition apparatus of claim 24, wherein both of a diameter D1 of the one end of the center electrode and a diameter D2 of the protrusion of the earth electrode are 2.3 mm or less and a discharge formed between the one end and the protrusion is 0.7 mm or less in distance.

28. (Previously presented) The ignition of claim 25, wherein the mounting bracket has an outer circumferential surface therearound on which a threaded part to be thread-coupled with the internal combustion engine is formed, a thread diameter of the threaded part being M12 or less.

29. (Previously presented) The ignition apparatus of claim 28, wherein the protruding length L of the protrusion on the earth electrode is 1.5 mm or less.

30. (Previously presented) The ignition apparatus of claim 29, wherein the protruding length L is 0.8 mm or less.

31. (Previously presented) The ignition apparatus of claim 27, wherein both of the one end of the center electrode and the protrusion of the earth electrode are 1 mm² or less in a sectional area.

32. (Previously presented) An ignition apparatus comprising: the ignition plug of claim 27; and an ignition power supply having an ignition coil for applying voltage to the center electrode and the earth electrode, the ignition coil being 22 mm or less in coil diameter.

33. (Previously presented) An ignition apparatus comprising:
a spark plug having:
a mounting bracket to be mounted to an internal combustion engine,
a center electrode insulatedly-supported by the mounting bracket, one end of which being a cylindrical form and exposedly extending from one end of the mounting bracket, and
an earth electrode having one end coupled with the one end of the mounting bracket and the other end on which one surface is formed to face to the one end of the center electrode, the one surface having a cylindrical protrusion being secured thereon and extending toward the center electrode so as to face the one end of the center electrode; and
an ignition power supply for applying voltage to the center electrode and the earth electrode so that the voltage is applied across the discharge gap, positive electric charges being applied to the center electrode by the ignition power supply when an ignition is started in the spark plug and an amount of ignition energy supplied from the ignition power supply to the spark plug being lower than 17 mJ,
wherein both of the one end of the center electrode and the protrusion of the earth electrode is 2.3 mm in diameter.

34. (Previously presented) The ignition apparatus of claim 23, wherein both of the one end of the center electrode and the protrusion of the earth electrode are 1 mm² or less in a sectional area.

35. (Previously presented) The ignition apparatus of claim 23, wherein the protrusion of the earth electrode is made of an alloy of which main composition is Pt and to which at least one component selected from the group consisting of Ir, Ni, Rh, W, Pd, Ru and Os is added.

36. (Previously presented) The ignition apparatus of claim 23, wherein the protrusion of the earth electrode is made of an alloy of which main composition is Pt and to which at least one component selected from the group consisting of 0 to 50 wt% of Ir, 0 to 40 wt% of Ni, 0 to 50 wt% of Rh, 0 to 30 wt% of W, 0 to 40 wt% of Pd, 0 to 30 wt% of Ru, and 0 to 20 wt% of Os is added.

37. (Previously presented) The ignition apparatus of claim 23, wherein the protrusion of the earth electrode is made of an alloy of which main composition is Ir and to which at least one component selected from the group consisting of Rh, Pt, Ni, W, Pd, Ru and Os is added.

38. (Previously presented) The ignition apparatus of claim 23, wherein the protrusion of the earth electrode is made of an alloy of which main composition is Ir and to which at least one component selected from the group consisting of 0 to 50 wt% of Rh, 0 to 50 wt% of Pt, 0 to 40 wt% of Ni, 0 to 30 wt% of W, 0 to 40 wt% of Pd, 0 to 30 wt% of Ru, and 0 to 20 wt% of Os is added.

39. (Currently amended) An ignition apparatus for an internal combustion engine, comprising:

a spark plug mounted to the internal combustion engine, wherein the spark plug comprises a mounting bracket mounted to the internal combustion engine; a center electrode insulatedly-supported by the mounting bracket, one end of which having a cylindrical form and extend so as to be exposed from one end of the mounting bracket; and an earth electrode having one

end coupled with said one end of the mounting bracket and having another end including a surface formed to face said one end of the center electrode, said surface having a cylindrical protrusion secured thereon and extending toward the center electrode so as to face said one end of the center electrode, a spacing formed between the one end of the center electrode and the protrusion of the earth electrode serving as a discharge gap, both the one end of the center electrode and the protrusion of the earth electrode being 2.3 mm or less in diameter, and the discharge gap being 0.7 mm or less in length between the one end of the center electrode and the protrusion of the earth electrode; and

an ignition coil for supplying less than 17 mJ of ignition energy to the spark plug to cause an ignition in the spark plug discharge gap and being 22 mm or less in coil diameter.

Claims 40-41. (Canceled).

42. (Currently amended) ~~The~~ An ignition apparatus of claim 40, wherein the ~~spark plug comprises: for an internal combustion engine, comprising~~

a spark plug mounted to the internal combustion engine, wherein the spark plug comprises a mounting bracket to be mounted to an the internal combustion engine;

a center electrode insulatedly-supported by the mounting bracket, one end of which being a pillar-like form and extending so as to be exposed from one end of the mounting bracket; and

an earth electrode having one end coupled with the said one end of the mounting bracket and having another end including one surface formed to face to the said one end of the center electrode, the one surface having a pillar-like protrusion secured thereon and extending toward the center electrode so as to face the one end of the center electrode, a spacing formed between the one end of the center electrode and the protrusion of the earth electrode serving being formed to serve as a discharge

gap, both of the one end of the center electrode and the protrusion of the earth electrode having a sectional area of 4.2 mm^2 or less at all positions perpendicularly crossing an axial direction of each of the one end and the protrusion, and the discharge gap being 0.7 mm or less in length between the one end of the center electrode and the protrusion of the earth electrode; and

an ignition coil supplying less than 17 mJ of ignition energy to the spark plug to cause an ignition in the discharge gap and being 22 mm or less in coil diameter.